(1)

# FINAL REPORT
# ON WORK CONDUCTED DURING THE COORDINATED EASTERN ARCTIC RESEARCH EXPERIMENT (CEAREX) UNDER GRANT N00014-90-J-1249



Roger Colony
*Polar Science Center, Applied Physics Laboratory*
*College of Ocean and Fishery Sciences, University of Washington*

Work conducted by the Polar Science Center under ONR Grant N00014-90-J-1249 during CEAREX consisted of three separate studies: oceanic heat flux at the ice-ocean interface, ice-draft topography, and the Ice Data Acquisition Project (IDAP).

## Oceanic Heat Flux at the Ice-Ocean Interface

To estimate the oceanic heat flux at the ice-ocean interface, we monitored 12 sites on a single, multiyear sea-ice floe drifting in the Arctic Ocean northeast of Svalbard. At each site, we measured (1) the vertical temperature gradient through the sea ice to estimate the conductive heat flux at the ice-ocean interface and (2) the change in ice thickness to estimate the heat flux associated with the melting and freezing at the ice-ocean interface. The oceanic heat flux was deduced as a residual of the total energy balance at the ice-ocean interface. The main results were as follows:

(1) The fluxes in this region were an order of magnitude greater than typical values found in the central basin.

(2) The growth rate differed from site to site.



(3) There were large differences in the turbulent oceanic heat flux from site to site.

The higher fluxes compared with the central basin are due to incorporation of warm



Atlantic water, either from the West Spitsbergen Current or from outflow from the Barents Sea, into the mixed layer. We believe that the variability in growth rate was due to an intrinsic instability in the phase boundary; the thermal regime for such an instability is consistent with laboratory experiments by other researchers. We initially speculated that the large variability in the turbulent heat flux was related to the geometry of the keels in the multiyear floe; this was subsequently verified by model simulations using the field data. The most important implication of this large variability is that a single measurement made close to the ice-ocean interface of a mature floe will yield information that is of questionable geophysical value. Overall, the results agree well with observed intrusions of warm water and are consistent with the turbulent oceanic heat flux measured directly at a nearby location. We have published three papers[1-3] on the large intersite variability found in the turbulent oceanic heat flux.

**The Topography of Ice Draft**

In cooperation with the Norwegian Polar Research Institute, we conducted an experiment on a multiyear ice floe in the eastern Arctic Ocean to study internal waves and other small-scale oceanographic features. This study was undertaken because interpretation of some of the oceanographic measurements was expected to depend on the geometric configuration of the ice draft. About 50,000 $m^2$ of ice was scanned with a Mesotech Sonar to resolve the spatial structure of under-ice features. The directional dependence of the oceanographic measurements was then related to the under-ice geometry. The results were consistent with the drift phase data and subsequent modeling.

**Ice Data Acquisition Program**

Also in cooperation with the Norwegian Polar Research Institute, we participated in the Ice Data Acquisition Program in the western Barents Sea. During a cruise of R/V *Lance* in March 1988, we tested equipment for measuring temperatures and energy fluxes

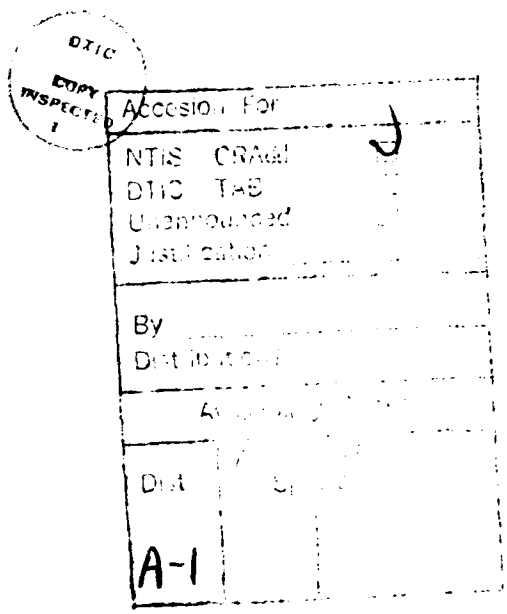
at the snow-ice and ice-ocean interfaces. We also developed a stochastic model of iceberg production, drift, and grounding, and used it to estimate probability density functions for the number of icebergs likely to be found in a prescribed geographical region. This model is presently being used in Norway. In a separate study, we examined the areal flux of multiyear ice into the western Barents Sea over a period of 30 years. Multiyear ice floes are the habitat of amphipods, which may live as long as 5 years attached to the same floe. Such floes may thus be an important food source for the fish of the western Barents. A stochastic model of ice motion suggests that most of the ice floes in the western Barents are formed in the Laptev and East Siberian seas.

## References

1. J. S. Wettlaufer, N. Untersteiner, and R. Colony, "Estimating oceanic heat flux from sea ice thickness and temperature data," *Annals of Glaciology, 14*, 315-318 (1990).

2. J. S. Wettlaufer, "Heat flux at the ice-ocean interface," *J. Geophys. Res.*, *96*, 7215–7236 (1991).

3. A. Omstedt and J. S. Wettlaufer, "Ice growth and oceanic heat flux: Models and measurements," *J. Geophys. Res.*, in press.




Statement A per telecon Dr. Thomas Curtin
ONR/code 1125
Arlington, VA 22217-5000

NWW 1/27/92